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SEMICONDUCTOR DEVICE WITH FIELD ELECTRODE STRUCTURES, GATE STRUCTURES AND AUXILIARY DIODE STRUCTURES

PRIORITY CLAIM

This application claims priority to German Patent Application No. 10 2014 113 189.4 filed on 12 Sep. 2014, the content of said application incorporated herein by reference in its entirety.

BACKGROUND

Power semiconductor devices used as switching devices typically include IGFET (insulated gate field effect transistor) cells. In a forward mode, a suitable potential at a gate electrode induces an inversion channel through a body zone. The inversion channel bypasses a reverse biased pn junction between the body zone and a drift zone. In a reverse blocking mode compensation structures extending from the front side into the semiconductor die deplete semiconductor mesas between the compensation structures such that the semiconductor mesas may have higher dopant concentrations without adverse impact on the blocking capability. High dopant concentrations in turn reduce the on-state resistance of the semiconductor device. Typical switching applications for power semiconductor devices include a switching cycle with the pn junction between the body zone and the drift zone being forward biased and conveying a switching current. A voltage drop across the forward biased pn junction between body zone and drift zone significantly contributes to the total switching losses in the semiconductor device in switching applications.

It is desirable to provide semiconductor devices with low switching losses.

SUMMARY

According to an embodiment a semiconductor device includes field electrode structures extending in a direction vertical to a first surface in a semiconductor body. Cell mesas are formed from portions of the semiconductor body between the field electrode structures and include body zones that form first pn junctions with a drift zone. Gate structures between the field electrode structures control a current flow through the body zones. Auxiliary diode structures with a forward voltage lower than the first pn junctions are electrically connected in parallel with the first pn junctions, wherein semiconducting portions of the auxiliary diode structures are formed in the cell mesas.

According to another embodiment an electronic assembly includes a semiconductor device including field electrode structures extending in a direction vertical to a first surface in a semiconductor body. Cell mesas are formed from portions of the semiconductor body between the field electrode structures and include body zones that form first pn junctions with a drift zone. Gate structures between the field electrode structures control a current flow through the body zones. Auxiliary diode structures with a forward voltage lower than the first pn junctions are electrically connected in parallel with the first pn junctions. Semiconducting portions of the auxiliary diode structures are formed in the cell mesas.

Those skilled in the art will recognize additional features and advantages upon reading the following detailed description and on viewing the accompanying drawings.

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BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification. The drawings illustrate the embodiments of the present invention and together with the description serve to explain principles of the invention. Other embodiments of the invention and intended advantages will be readily appreciated as they become better understood by reference to the following detailed description.

FIG. 1A is a schematic vertical cross-sectional view of a portion of a semiconductor device according to an embodiment related to auxiliary diode structures which semiconducting portions are formed in cell mesas between gate and field electrode structures.

FIG. 1B is a schematic circuit diagram of an IGFET cell illustrated in FIG. 1A.

FIG. 2A is a schematic vertical cross-sectional view of a portion of a semiconductor device according to an embodiment related to a Schottky diode formed in a cell mesa and directly adjoining a field electrode structure.

FIG. 2B is a schematic diagram showing forward characteristics of semiconductor devices for discussing effects of the embodiments.

FIG. 2C is a schematic diagram showing blocking characteristics of semiconductor devices for discussing effects of the embodiments.

FIG. 3A is a schematic vertical cross-sectional view of a portion of a semiconductor device according to an embodiment related to a Schottky contact formed along a cell mesa and directly adjoining a field electrodes.

FIG. 3B is a schematic vertical cross-sectional view of a portion of a semiconductor device in accordance with an embodiment related to a Schottky contact based on a conductive structure between a first surface of a semiconductor body and the field electrode structure.

FIG. 3C is schematic horizontal cross-sectional view of the semiconductor device portion of FIG. 3B along line C-C.

FIG. 3D is a schematic vertical cross-sectional view of a portion of a semiconductor device in accordance with an embodiment related to a Schottky contact formed at a tip of a conductive structure spaced from field electrode and gate structures and extending into the cell mesa.

FIG. 4A is a schematic horizontal cross-sectional view of a portion of a semiconductor device according to an embodiment related to Schottky contacts and gate electrodes formed in field electrode trenches, respectively.

FIG. 4B is a schematic vertical cross-sectional view of the semiconductor device portion of FIG. 4A along line B-B.

FIG. 5A is a schematic horizontal cross-sectional view of a portion of a semiconductor device in accordance with an embodiment related to MGDs (MOS gated diodes) and needle-shaped field electrode structures alternately arranged in lines.

FIG. 5B is a schematic vertical cross-sectional view of the semiconductor device portion of FIG. 5A along line B-B.

FIG. 5C is a schematic vertical cross-sectional view of the semiconductor device portion of FIG. 5A along line C-C.

FIG. 6A is a schematic horizontal cross-sectional view of a portion of a semiconductor device in accordance with an embodiment related to MGDs and field electrode structures alternately arranged and connected with each other along lines.

FIG. 6B is a schematic vertical cross-sectional view of the semiconductor device portion of FIG. 6A along line B-B.